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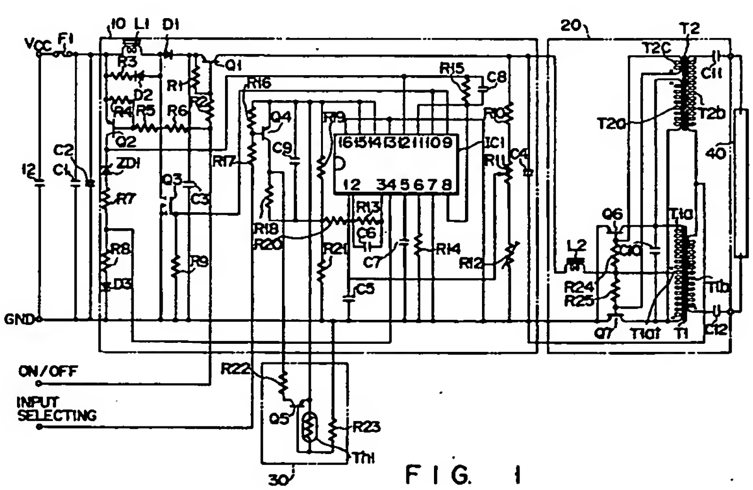
(71) Applicant: **TOSHIBA LIGHTING & TECHNOLOGY CORPORATION**
4-28, Mita 1-chome
Minato-ku Tokyo(JP)

(72) Inventor: **Kimura, Mitsutoshi**
1-45-4, Koyabe
Yokosuka-shi, Kanagawa-ken(JP)
Inventor: **Ishizuka, Akio**
1-34-2-205, Tomiokanishi, Kanazawa-ku
Yokohama-shi(JP)
Inventor: **Nakano, Katsuaki**
2-19-3-A-201, Kodai, Miyamae-ku
Kawasaki-shi(JP)
Inventor: **Onodera, Yoshinobu**
Daisan-Tachibana-So,5-3-3-, Shinsaku
Takatsu-ku, Kawasaki-shi(JP)
Inventor: **Satou, Yoshinori**
6-1-45-406, Konandai, Konan-ku
Yokohama-shi(JP)

(74) Representative: **Henkel, Feiler, Hänzel & Partner**
Möhlstrasse 37
W-8000 München 80(DE)

(54) Apparatus for operating discharge lamp.

(57) An apparatus for operating a discharge lamp variably permits a stable power supply circuit (10) to set the lamp current of a discharge lamp (40) in two or greater levels. A temperature detector (30) detects the temperature of the discharge lamp (40). When the lamp current set by the stable power supply circuit (10) is equal to or below a predetermined value and the temperature is equal to or below a predetermined level, the lower limit of the lamp current is increased. Accordingly, the discharge lamp (40) is lit through an inverter circuit (20) with the raised voltage so as to prevent lighting failure from occurring in the discharge lamp (40) due to a low lamp current at a low temperature.



F I G. 1

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The present invention relates to an apparatus for operating a discharge lamp, particularly to an apparatus for operating a discharge-lamp capable of changing the lower limit of the lamp current at a low temperature.

A conventional apparatus for operating a discharge lamp, for example, a back light for use in an electronic device, such as a computer, is known which can change the lamp current whether either a battery or a commercially available AC power supply is used. When the AC power supply is used, for example, the luminance of the discharge lamp is set high regardless of power consumption in the electronic device. When the battery is used, the luminance of the discharge lamp drops to a lower level to save the power, thus ensuring a longer use of the discharge lamp with the battery.

If the lamp current of the discharge lamp is reduced to save the power, however, lighting failure may occur at a lower temperature. On the contrary, with the current for the discharge lamp set to a certain high level, the power consumption cannot be sufficiently suppressed.

It is therefore an object of the present invention to provide a apparatus for operating a discharge lamp which can sufficiently suppress power consumption even when a lamp current is set low, and hardly causes lighting failure at a low temperature.

According to one aspect of the present invention, there is provided an apparatus for operating a discharge lamp which comprises a discharge lamp; power supply means, connected to the discharge lamp, capable of setting a value of a lamp current of the discharge lamp in at least two levels; a DC power supply section, connected to the power supply means, for supplying a predetermined voltage; temperature detecting means, connected to the power supply means, for detecting a temperature of the discharge lamp or the ambient temperature thereof; and control means for performing control to allow the lamp current set by the power supply means to increase when the temperature detected by the temperature detecting means is equal to or below a given temperature, and the value of the lamp current is set equal to or below a predetermined value by the power supply means.

According to another aspect of the present invention, there is provided an apparatus for operating a discharge lamp which comprises a discharge lamp; power supply means, connected to the discharge lamp, capable of setting a value of a lamp current of the discharge lamp in at least two levels; a DC power supply section, connected to the power supply means, for supplying DC voltages corresponding to the at least two levels; temperature detecting means, connected to the power supply means, for detecting a temperature of the discharge lamp or the ambient temperature thereof; and control means for performing control to allow the lamp current set by the power supply means to increase when the temperature detected by the temperature detecting means is equal to or below a given temperature, and the value of the lamp current is set equal to or below a predetermined value by the power supply means.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagram illustrating the circuit structure of a lighting apparatus for a discharge lamp according to one embodiment of the present invention;

Fig. 2 is a graph showing the relationship between an inverter input voltage and the ambient temperature in the operation of the discharge-lamp lighting apparatus in Fig. 1; and

Fig. 3 is a diagram illustrating the circuit structure of a lighting apparatus for a discharge lamp according to another embodiment of the present invention.

One preferred embodiment of the present invention will now be described referring to the accompanying drawings.

Fig. 1 illustrate the circuit structure a lighting apparatus for a discharge lamp according to this embodiment of the present invention. A capacitor C1 and an electrolytic capacitor C2 are connected in parallel as filters via a DC power supply 12 and a fuse F1. A variable stable power supply 10 and an inverter circuit 20 are connected in series to the electrolytic capacitor C2. A temperature detector 30 as temperature detecting means is connected to the variable stable power supply 10. A discharge lamp 40 is connected to the inverter circuit 20.

In the variable stable power supply 10, an inductor L1 (used for accumulating power), a diode D1 having the polarity shown in Fig. 1 and used for preventing a reverse current flow, and the emitter of an ON/OFF transistor Q1 are connected in the named order to the fuse F1. A bias resistor R1 is connected between the base and emitter of the transistor Q1 whose base is connected via a resistor R2 to an ON/OFF terminal.

A series circuit including a resistor R3 and a diode D2 is connected in parallel to the inductor L1. The emitter of the transistor Q2 is connected to a point where the fuse F1 is connected to the inductor L1. A bias resistor R4 is connected between the emitter and base of the transistor Q2 whose base is connected to the ON/OFF terminal via resistors R5 and R6. The transistor Q2 has its collector connected to a GND terminal via a Zener diode ZD1, resistors R7 and R8 and a diode D3.

Connected to a connecting point between the inductor L1 and the diode D1 is the drain of a field-

effect transistor Q3 which changes a duty ratio to vary the output of the variable stable power supply 10. The source of the transistor Q3 is connected to the GND terminal. A resistor R9 is connected between the source and drain of the transistor Q3. A capacitor C3 is connected between the cathode of the diode D1 and the GND terminal. A series circuit which has a resistor R10, a variable resistor R11 and a semi-fixed resistor R9, and a smoothing electrolytic capacitor C4 are connected in parallel between the collector of the transistor Q1 and the GND terminal. The variable resistor R11 serves as a volume to change the dimming of the discharge lamp 40.

"IC1" is, for example, a TL494 IC chip produced by Texas Instrument Corp. The IC chip IC1 has its terminal 1 connected to the GND terminal via a capacitor C5. A resistor R13 and a capacitor C6 are connected in parallel to each other between terminals 2 and 3 of the IC chip IC1. A connecting point between the resistors R7 and R8 is connected to a terminal 4 of the IC chip IC1. The IC chip IC1 also has terminals 5 and 6 connected to the GND terminal respectively via a capacitor C7 and a resistor R14. Terminals 7, 13 and 16 of the IC chip IC1 are directly connected to the GND terminal.

The IC chip IC1 has terminals 8 and 11 connected to the collector of the transistor Q2 via a parallel circuit including a resistor R15 and a capacitor C8, and has a terminal 12 directly connected to the collector of the transistor Q2. Terminals 14 and 15 of the IC chip IC1 are connected to the emitter of a transistor Q4 for selecting an input in accordance with switching between the commercially available AC power supply and the battery, for example. A bias resistor R16 is connected between the emitter and base of the transistor Q4, with an input selecting terminal connected to that base. A resistor R18 is connected to the collector of the transistor Q4, while a parallel circuit having an electrolytic capacitor C9 and a resistor R19 is connected via the resistor R18 between the collector and the emitter of the transistor Q4. A point where the resistor R18, the electrolytic capacitor C9 and the resistor R19 are connected is connected via a resistor R20 to a parallel circuit having a resistor R13 and a capacitor C6, and also connected to the GND terminal via a resistor R21.

The capacitor C9 and resistors R19 and R21 form a time constant circuit. Even if the time constant circuit is in a dimming state, it supplies a high power to the discharge lamp 40 at the start thereof, thereby enabling the lamp to start discharging and light up in a reliable manner. Capacitor C9 of the time constant circuit prevents a rapid decrease in the brightness of the lamp 40 in the case where transistor Q4 is changed from ON to OFF by a signal supplied from the input selecting terminal.

The temperature detector 30 has a transistor Q5. The transistor Q5 has a collector connected via a resistor R22 to the collector of the transistor Q4, an emitter connected to the emitter of the transistor Q4, and a base connected via a resistor R23 to the GND terminal. Connected between the emitter and base of the transistor Q5 is a thermistor Th1 which is attached to, for example, the wall of the tube of the discharge lamp 40.

The inverter circuit 20 is connected between one end of the electrolytic capacitor C4 as the positive terminal of the variable stable power supply 10, and the other end as the negative terminal thereof. An intermediate tap T1at of a primary winding T1a of a first transformer T1 is connected via an inductor L2 in the inverter circuit 20 to the positive terminal of the variable stable power supply 10. A resonance capacitor C10 is connected to the primary winding T1a in parallel. The primary winding T1a has one end connected via the collector and emitter of a transistor Q6 to the negative terminal of the variable stable power supply 10. The other end of the primary winding T1a is connected via the collector and emitter of a transistor Q7 to the negative terminal of the variable stable power supply 10.

The bases of the transistors Q6 and Q7 as control terminals are connected respectively via resistors R24 and R25 to a connecting point between the inductor L2 and the intermediate tap T1at. A second transformer T2 has its primary winding T2a connected in parallel to the primary winding T1a of the transformer T1 and the capacitor C10. The second transformer T2 has a control winding T2c connected to the bases of the transistors Q6 and Q7.

The first transformer T1 and the second transformer T2 have the secondary winding T1b and second winding T2b connected in series via capacitors C11 and C12 to the discharge lamp 40, or, for example, a cold-cathode tube for a back light used in an office automation device. The secondary winding T1b of the first transformer T1 and the secondary winding T2b of the second transformer T2 are commonly grounded and are connected to the negative terminal of the variable stable power supply 10.

The operation of this embodiment will now be described.

To begin with, the operation by the commercially available AC power supply in use will be explained.

When the lighting apparatus is driven by the commercially available AC power supply, an input signal from the input selecting terminal becomes a low level, rendering the transistor Q4 on and the temperature detector 30 off. Voltages to be applied

to the terminals 1, 2 and 4 of the IC chip IC1 are raised, and the width of a PWM modulated pulse output from the terminals 9 and 10 of the IC chip IC1 becomes relatively large. The ON duration of the field-effect transistor Q3 increases, and the output of the variable stable power supply 10 is increased. Even if the thermistor Th1 in the temperature detector 30 detects a temperature equal to or below a predetermined temperature, for example, about 15°C, the temperature detector 30 is short-circuited by the transistor Q4, so that the output of the variable stable power supply 10 does not change.

When the resistance of the variable resistor R11 is changed to alter the amount of dimming, an arbitrary voltage within the range A from 16.5 V to 24 V in Fig. 2 (range where dimming is possible) is held constant, regardless of the temperature.

The output of the variable stable power supply 10 becomes constant by changing the resistance of the variable resistor R11 through feedback control.

The operation with the battery in use will now be explained.

When the lighting apparatus is driven by the battery, the input signal from the input selecting terminal becomes a high level, rendering the transistor Q4 off. The width of a PWM modulated pulse output from the terminals 9 and 10 of the IC chip IC becomes relatively small. The ON duration of the field-effect transistor Q3 decreases. The output of the variable stable power supply 10 decreases so that the brightness of the discharge lamp 40 is about 30% of that in the case where the AC power is used.

When the thermistor Th1 of the temperature circuit 30 detects a temperature of 15°C or lower, the resistance of the thermistor Th1 is raised to render the transistor Q5 on. The width of a PWM modulated pulse output from the terminals 9 and 10 becomes a little larger, and the ON duration of the field-effect transistor Q3 is also increased slightly. The output of the variable stable power supply 10 is increased so that the brightness of the discharge lamp 40 becomes 45% of that in the case where the AC power is used, thus preventing the lighting failure of the discharge lamp 40.

If the temperature is 15°C or above, the proper voltage is selected within the range of 11 V to 15 V as indicated by B1 or B2 in Fig. 2, for example, by changing the resistance of the variable resistor R11. If the temperature is below 15°C, the voltage increases. In other words, when the temperature is below 15°C, the voltage is held at about 15 V, no matter where in the range of 11 V to 15 V the set voltage is. R19a (broken lines) and R19b (real line) in Fig. 2 indicate changes in output of the power supply (input of the inverter circuit) when different discharge lamps with different resistors R19 are used.

In other words, the output characteristic curves indicated by R19a and R19b show the operational limit of the discharge lamp 40 driven by the battery when the resistor R19 is used.

Whether the AC power or the battery is used, the DC current from the variable stable power supply 10 is supplied via the inductor L2 for a constant current and either transistor Q1 or Q2 is rendered on, so that the inverter circuit 20 is activated.

In accordance with a control output induced in the control winding T2c, the transistors Q6 and Q7 are alternately turned on. When the transistor Q6 is turned on, the current flows in a closed circuit from the variable stable power supply 10, to the inductor L2, to the half of the primary winding T1a of the first transformer T1, to the transistor Q6, and then back to the variable stable power supply 10. Thus, the capacitor C10 resonates with the primary winding T1a, and hence a high frequency voltage having a substantial sine waveform is created in the secondary winding T1b. A voltage similar to this sine wave voltage is created in the secondary winding T2a of the second transformer T2, parallel connected to the primary winding T1a. The voltages of the secondary winding T1b of the first transformer T1 and the secondary winding T2b of the second transformer T2 are added to each other, and the resultant voltage is applied to the discharge lamp 40.

Then, the resonance voltage is inverted, and the transistor Q6 is turned off. When the transistor Q7 is turned on, the current flows in a closed circuit from the variable stable power supply 10, to the inductor L2, to the half of the primary winding T1a of the first transformer T1, to the second transformer T2, and then back to the variable stable power supply 10. Thus, the capacitor C10 resonates with the primary winding T1a, and hence a high frequency voltage having a substantial sine waveform is created in the secondary winding T1b. A voltage similar to this sine wave voltage is created in the secondary winding T2a of the second transformer T2, parallel connected to the primary winding T1a. A voltage is induced, in the opposite direction to that in the previous case, in the secondary winding T2b of the second transformer T2. The voltages of the secondary winding T1b of the first transformer T1 and the secondary winding T2b of the second transformer T2 are added to each other, and the resultant voltage is applied to the discharge lamp 40.

According to this embodiment, though the output of the discharge lamp 40 is reduced to save the power with the battery in use, the output of the discharge lamp 40 rises when the temperature

drops to a predetermined degree or lower. Lighting failure can be prevented. The output of the discharge lamp 40, when the battery is used, can be determined in consideration of only lighting failure of the discharge lamp 40 at the normal temperature. The output of the discharge lamp 40 can therefore be suppressed very low to save the power sufficiently. Since the output of the discharge lamp 40 does not increase at a low temperature when the AC power is used, the discharge lamp 40 is not influenced by the low temperature.

The voltage of the discharge lamp 40 is acquired by superimposing the voltages induced in the secondary windings T1b and T2b of the first and second transformers T1 and T2, respectively. Thus, the voltages to be induced in secondary windings T1b and T2b can be low, thus permitting the first and second transformers T1 and T2 to be designed compact.

The thermistor Th1 in the temperature detector 30 may be attached not only to the tube wall of the discharge lamp 40, but also to the radiating plate of the transistor, capacitor, coil or the like.

Fig. 3 illustrates the circuit structure of a lighting apparatus for a discharge lamp according to another embodiment of the present invention. A DC power supply 14, which provides a DC voltage acquired by rectifying commercially available AC power and a battery 16 are connected in parallel to each other via power switches SW1 and SW2 between the Vcc terminal and the GND terminal. An input selecting switch SW3 interposed between the input switching terminal and ground line is associated with the switches SW1 and SW2. The other structure in this circuit is the same as that of the circuit shown in Fig. 1, so that their otherwise redundant description will be omitted.

In the lighting apparatus with the structure shown in Fig. 3, when the switch SW1 is on, and the switch SW2 is off, the input selecting switch SW3 is on. The DC power supply 14 is thus connected between the Vcc terminal and the GND terminal. Since the input selecting switch SW3 is on this time, the transistor Q4 is rendered on, turning off the temperature detector 30. The operation associated with this event is the same as that in the first embodiment, so that its description will be omitted.

When the switch SW1 is off, and the switch SW2 is on, the input selecting switch SW3 is off. The battery 16 is therefore connected between the Vcc terminal and the GND terminal. Since the input selecting switch SW3 is off this time, the transistor Q4 is rendered off. The operation associated with this event is the same as that in the first embodiment, so that its description will be omitted.

As described above, the type of the power supply to be connected is selected by switching the input selecting switch SW3. With the battery 14 in use, even if the output of the discharge lamp 40 is decreased to save the power, the output of the discharge lamp 40 is raised when the temperature drops to a predetermined value or lower, thus preventing lighting failure.

Claims

1. An apparatus for operating a discharge lamp comprising a discharge lamp, power supply means, connected to said discharge lamp, capable of setting a value of a lamp current of said discharge lamp in at least two levels; a DC power supply section, connected to said power supply means, for supplying a predetermined voltage, and control means for performing control to allow said lamp current set by said power supply means to be variable when said value of said lamp current is set equal to or below a predetermined value by said power supply means, characterized by further comprising, temperature detecting means (30), connected to said power supply means (10), for detecting a temperature of said discharge lamp (40) or the ambient temperature thereof, characterized in that said control means (IC1) performs control to allow said lamp current set by said power supply means (10) to increase said temperature detected by said temperature detecting means (30) is equal to or below a given temperature, and said value of said lamp current of said discharge lamp (40) is set equal to or below a predetermined value by said power supply means (10).

2. An apparatus according to claim 1, characterized in that said control means (IC1) performs control to change a lower limit of said lamp current set by said power supply means (10) and supply said lamp current to said discharge lamp (40) when said temperature detected by said temperature detecting means (30) is equal to or below said given temperature, and said value of said lamp current of said discharge lamp (40) is set equal to or below said predetermined value by said power supply means (10).

3. An apparatus according to claim 2, characterized in that said control means (IC1) performs control to increase said lower limit of said lamp current set by said power supply means (10) and supply said lamp current to said discharge lamp (40) when said temperature detected by said temperature detecting means (30) is equal to or below said given temperature, and said value of said lamp current of said discharge

lamp (40) is set equal to or below said predetermined value by said power supply means (10).

4. An apparatus for operating a discharge lamp comprising a discharge lamp, power supply means, connected to said discharge lamp, capable of setting a value of a lamp current of said discharge lamp in at least two levels; a DC power supply section, connected to said power supply means, for supplying a predetermined voltage corresponding to said at least two levels, and control means for performing control to allow said lamp current set by said power supply means to be variable when said value of said lamp current is set equal to or below a predetermined value by said power supply means, characterized by further comprising, temperature detecting means (30), connected to said power supply means (10), for detecting a temperature of said discharge lamp (40) or the ambient temperature thereof, characterized in that said control means (IC1) performs control to allow said lamp current set by said power supply means (10) to increase said temperature detected by said temperature detecting means (30) is equal to or below a given temperature, and said value of said lamp current of said discharge lamp (40) is set equal to or below a predetermined value by said power supply means (10).

5. An apparatus according to claim 4, characterized in that said control means (IC1) performs control to change a lower limit of said lamp current set by said power supply means (10) when said temperature detected by said temperature detecting means (30) is equal to or below said given temperature, and said value of said lamp current of said discharge lamp (40) is set equal to or below said predetermined value by said power supply means (10).

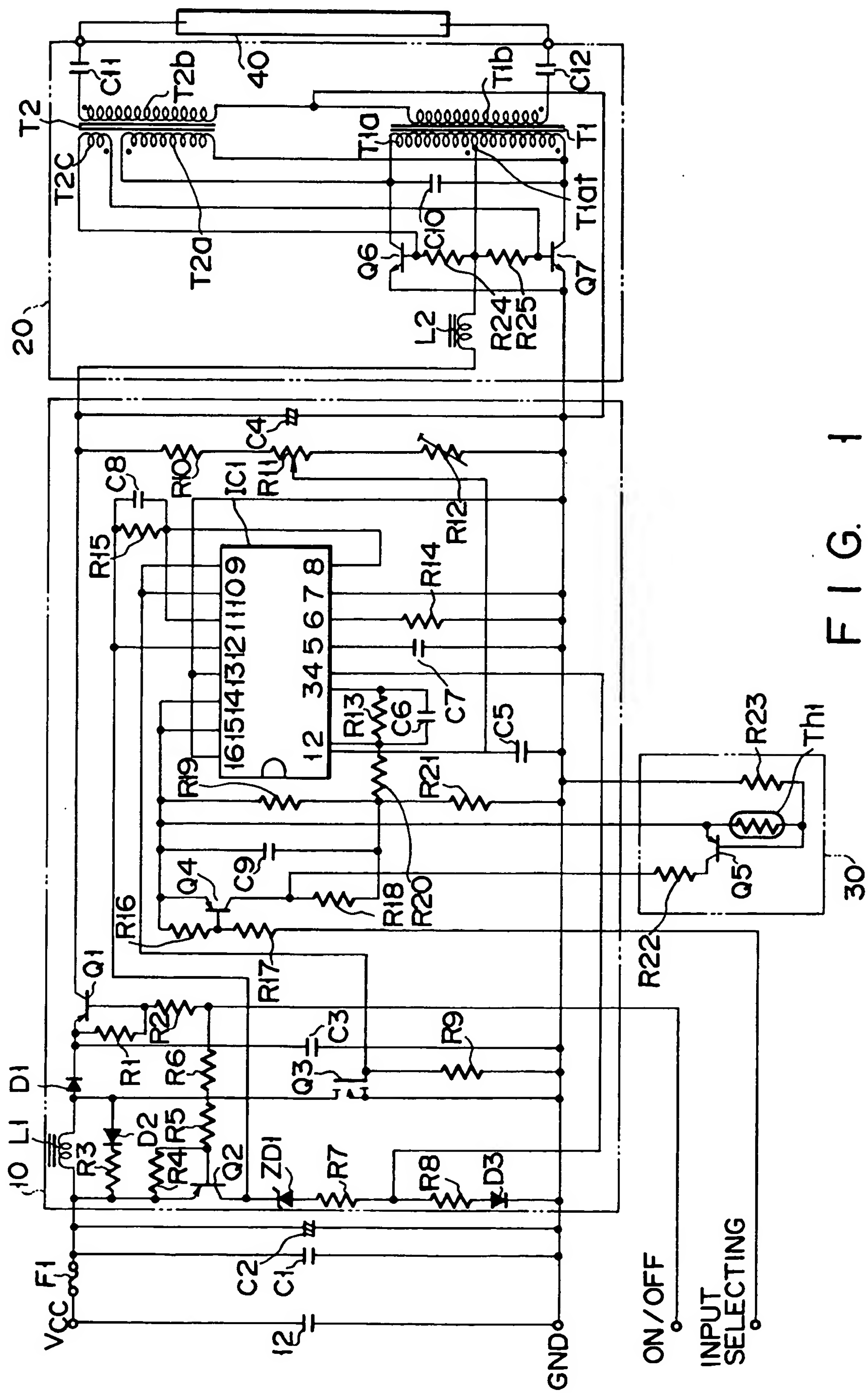
6. An apparatus according to claim 5, characterized in that said control means (IC1) performs control to increase said lower limit value of said lamp current set by said power supply means (10) when said temperature detected by said temperature detecting means (30) is equal to or below said given temperature, and said value of said lamp current of said discharge lamp (40) is set equal to or below said predetermined value by said power supply means (10).

7. An apparatus according to claim 4, characterized in that said DC power supply section includes a first DC power supply section (14) for setting said lamp current of said discharge lamp high, and a second DC power supply section (16) for setting said lamp current lower than that set by said first DC power supply section (14).

8. An apparatus according to claim 7, characterized by further comprising first switch means (SW3) for switching at least between said two levels of said lamp current of said discharge lamp (40) from said power supply means (10), and second switch means (SW1, SW2), connected between said power supply means (10) and said first and second DC power supply sections (14, 16), for switching between said first DC power supply section (14) and said second DC power supply section (16), thereby cooperating with said first switch means (SW3).

9. An apparatus according to claim 3, characterized by further comprising switch means (Q4) to be turned on and off in accordance with switch signals input thereto, and a time constant circuit having a capacitor element (C9) and resistors (R20, R21) and connected in parallel to the switch means (Q4), the capacitor element (C9) being connected in parallel to the switch means(Q4).

10. An apparatus according to claim 8, characterized by further comprising third switch means (Q4) provided for the power supply means (10), and to be turned on and off in accordance with changeover of the second switch means (SW1, SW2), and a time constant circuit having a capacitor element (9) and resistors (R20, R21) and connected in parallel to the third switch means (Q4), the capacitor element (C9) being connected in parallel to the third switch means (Q4).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R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
Q1
Q2
Q3
Q4
Q5
ZD1
C3
C4
C5
C6
C7
C8
C9
IC1
16 15 14 13 12 11 10 9
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Th1
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20
L2
Q6
Q7
R24
R25
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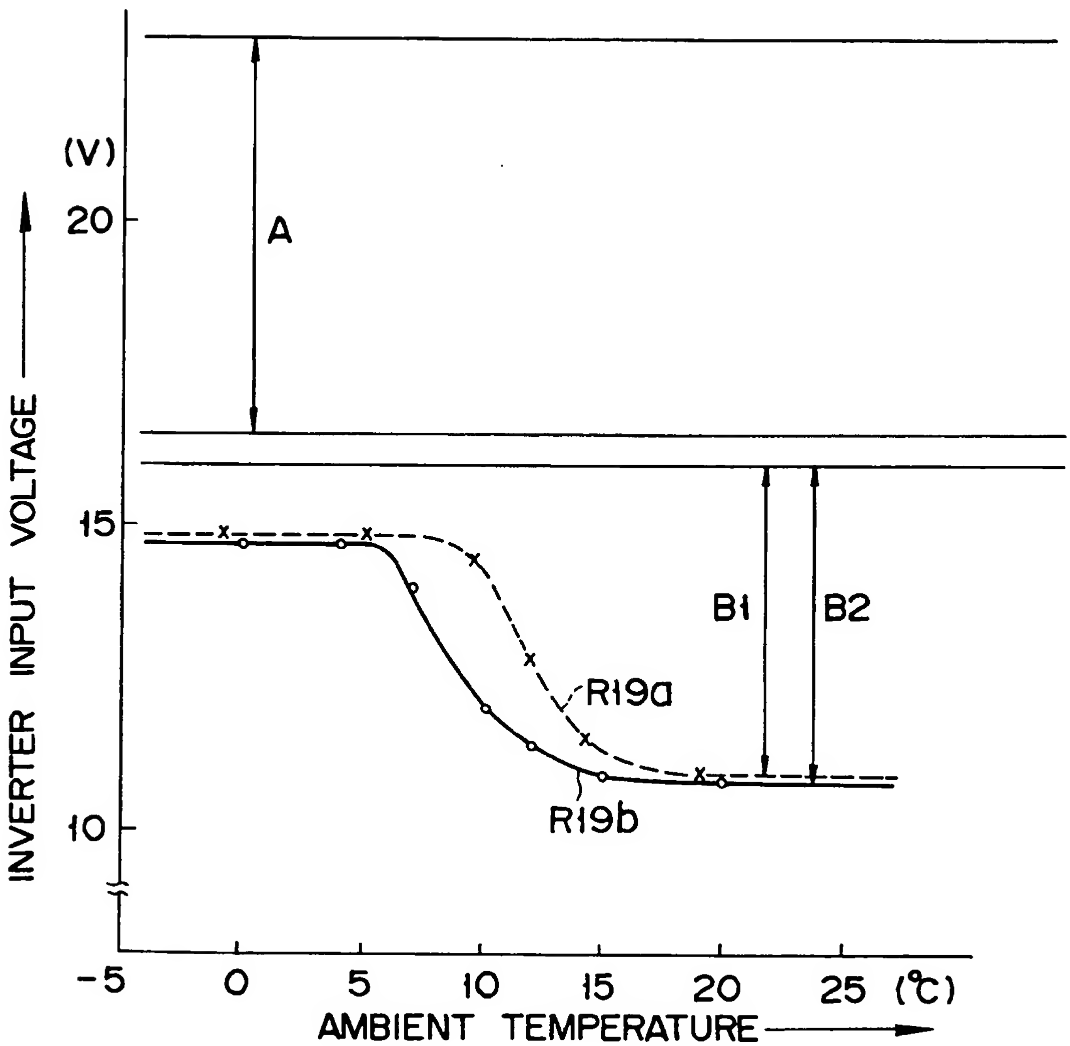
F I G 1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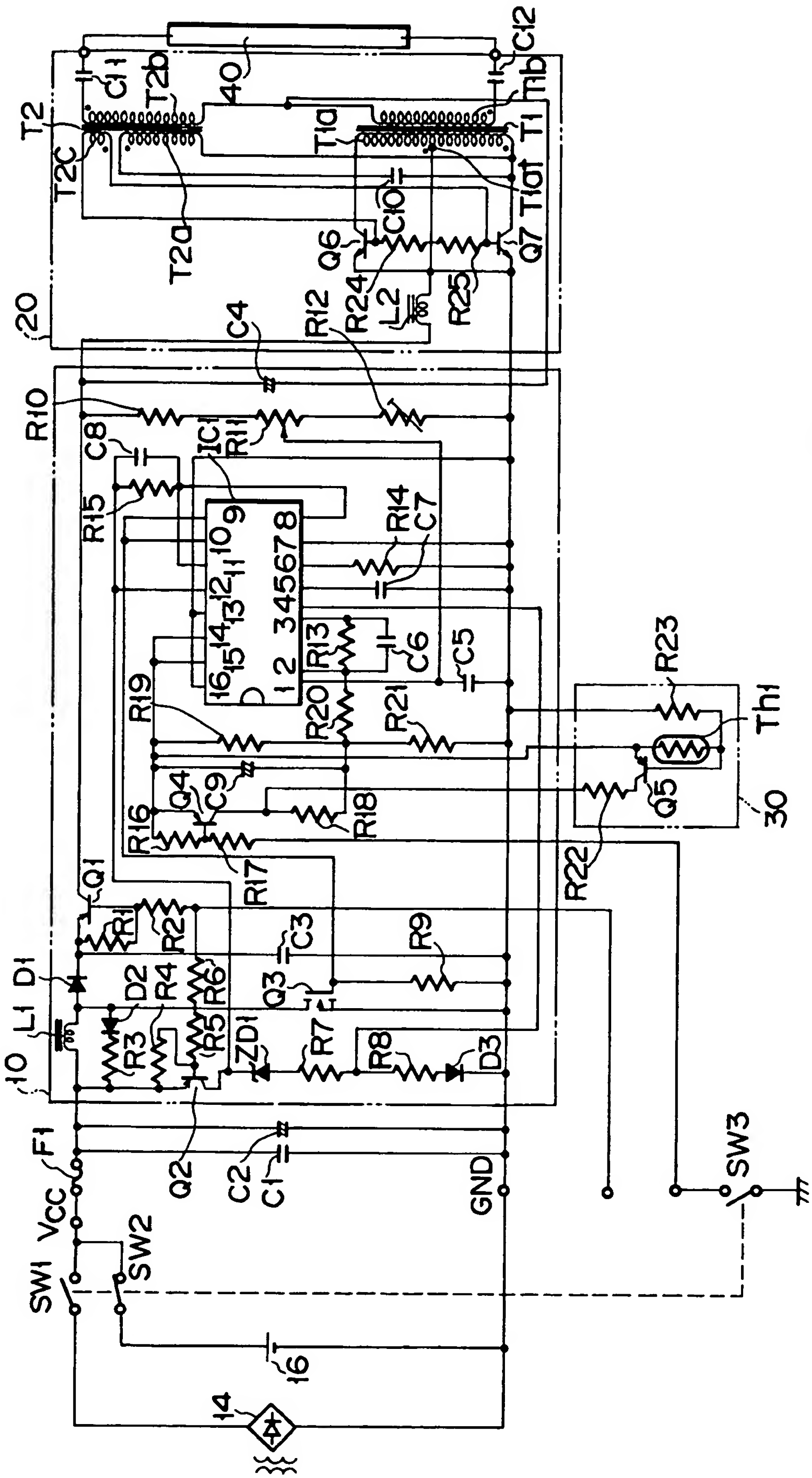
F I G. 2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R3
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Q3
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SW1
SW2
16
14

F I G. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91116369.9

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP - A - 0 164 774 (PHILIPS) * Abstract; fig. 1-3; claims 1-9 *	1,4	H 05 B 41/36
A	GB - A - 2 090 082 (G.E.C) * Abstract; fig. 1; claims 1-14 *	1,4	
A	EP - A - 0 349 707 (WIDE-LITE INTERNATIONAL CORP.,) * Abstract; fig. 1 *	1,4	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 05 B 41/00
H 05 B 39/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	19-12-1991	VAKIL

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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